DECLARATION

I, Taro MATSUNAMI, a citizen of Japan, c/o Miyoshi & Miyoshi of Toranomon Kotohira Tower, 2-8, Toranomon 1-chome, Minato-ku, Tokyo 105-0001, Japan, do hereby solemnly and sincerely declare:

That I am well acquainted with the Japanese language and English language; and

That the attached is a true and faithful translation made by me of the Japanese document, namely Japanese Patent Application No.2003-422836 to the best of my knowledge and belief.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-captioned application or any patent issuing therefrom.

This 20th day of February, 2008

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[NAME OF DOCUMENT] Patent application

[REFERENCE NUMBER] HTK-835

[FILING DATE] December 19, 2003

[DESTINATION] Commissioner of the Patent Office

[INTERNATIONAL PATENT CLASSIFICATION] G02B 6/00 331

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[INDICATION OF FEE]

[NUMBER OF DEPOSIT ACCOUNT] 001982

[PAYMENT] 21,000 yen

[LIST OF ATTACHED DOCUMENTS]

[NAME OF ARTICLE] One Copy of Claims

[NAME OF ARTICLE] One copy of specification

[NAME OF ARTICLE] One copy of drawing

[NAME OF ARTICLE] One copy of abstract

[NUMBER OF GENERAL POWER OF ATTORNEY] 0302311

[Name of Document] Claims

[Claim 1]

A backlight device comprising at least a light source, a light guide plate and a reflector wherein

the light guide plate further provides an entry face into which light from the light source is incident, a lower face substantially perpendicular to the entry face and that opposes the reflector, and an upper face that opposes the lower face;

the light guide plate guides light entering from the entry face such that the light undergoes total reflection between the upper face and the lower face; and

reflective elements that reflect light such that light is emitted from the lower face toward the reflector are disposed on the upper face of the light guide plate integrally with the light guide plate.

[Claim 2]

The backlight device according to claim 1 wherein the reflector has reflective grooves disposed on the surface thereof that reflect light emitted from the lower face of the light guide plate to the light guide plate side.

[Claim 3]

The backlight device according to any one of claim 1 or 2 wherein the reflector has a metallic film disposed on the surface thereof.

[Claim 4]

The backlight device according to any one of claims 1 to 3 wherein the light guide plate is comprised of polymethyl metacrylate, a polyolefine resin, polycarbonate or a compound of these.

[Claim 5]

The backlight device according to any one of claims 1 to 5 wherein the distance between the upper face and the lower face of the light guide plate is 0.3-3 .0 mm.

[Claim 6]

The backlight device according to any one of claims 1 to 5 wherein the reflective elements are formed by disposing a plurality of V-shaped grooves on the upper face of the light guide plate substantially parallel to the entry face.

[Claim 7]

The backlight device according to claim 6 wherein

the reflective elements comprise:

the first face that is inclined toward the side of the light guide plate closest to the light source viewed from inside the light guide plate and

the second face that is inclined toward the face opposite the light source viewed from inside the light guide plate, and

the angle θ1 formed between the first face and the upper face is 0.2-5° and the angle θ2 formed between the second face

and the upper face is not more than 90°.

[Claim 8]

The backlight device according to any one of claim 1 or 2 wherein an anisotropic diffusion pattern is formed as an integrated body with the lower face of the light guide plate.

[Claim 9]

The backlight device according to claim 8 wherein the anisotropic diffusion pattern is a surface relief hologram.

[Claim 10]

The backlight device according to any one of claims 1 to 9 wherein

an optical sheet that deflects light emitted from the light guide plate so as to approach traveling direction of light to the direction normal to the upper face of the light guide plate is disposed in a position opposing the upper face of the light guide plate.

[Claim 11]

A liquid crystal display device comprising a backlight device according to any of claims 1 to 10 and liquid crystal display elements illuminated by this backlight device.

[Name of Document] Description

[Title of the Invention] BACK LIGHT DEVICE AND LIQUID CRYSTAL DISPLAY DEVICE

[Technical Field]

[0001]

The present invention relates to a backlight device that illuminates liquid crystal display elements or the like from the rear and a liquid crystal display device that provides this back light device and liquid crystal display elements.

[0002]

In conventional art a liquid crystal display device provides the display device used for a mobile telephone or the like. In this kind of liquid crystal display device a backlight device providing a light source together with a light guide plate that guides light emitted from this light source is used in order to provide illumination from the rear face of liquid crystal display elements.

[0003]

Fig. 14 provides an external view of a conventional light guide plate. Fig. 14 (a) provides a view of the light guide plate from above, Fig. 14 (b) provides a side view of the light guide plate and Fig. 14 (c) provides a perspective view of the light guide plate. In those drawings the light source is provided by light emitting diode (102).

[0004]

The light guide plate (101) is comprised of a transparent material such as PMMA or polycarbonate or the like and has a

substantially flat, planar form. The upper face of the light guide plate (101) comprises the exit face (103), the lower face comprises the reflective face (104) and one of the side faces comprises the entry face (105). Reflective elements (106) that operate to reflect light incident to the entry face (105) toward the exit face (103) are formed on the reflective face (104).

[0005]

Light output from the light emitting diode (102) light source enters the light guide plate (101) from the entry face (105). Light is deflected by the reflective elements (106) formed on the reflective face (104) in the direction of the exit face (103), and exits from the exit face (103). The light guide plate (101) in which light input from the entry face (105) comprising a side face is output from the exit face (103) comprising the main face is called a side edge type, and is widely used for mobile telephone devices and the like.

[0006]

Fig. 15 is a cross section showing the condition of usage of a conventional light guide plate and backlight device.

[0007]

The light guide plate (101) is arranged such that directly below the liquid crystal display elements (107), the exit face (103) is disposed opposing the lower face (109) of the liquid crystal display elements (107) with the optical sheet (108) positioned between the exit face (103) and that lower face. In the light guide plate (101), light from the light emitting diode (102) enters from the entry face (105).

[0008]

Light from the entry face (105) incident to the light guide plate (101) is deflected by the reflective elements (106) formed on the reflective face (104) opposing the exit face (103). The light is incident vertically to the lower face (109) of the liquid crystal display elements (107) and exits from the exit face (103).

[0009]

Light output from the exit face (103) of the light guide plate (101) enters the lower face (109) of the liquid crystal display elements (107) via the optical sheet (108). The optical sheet (108) directs the light output from the light guide plate (101) up in the direction of the liquid crystal display elements (107) such that the light is incident vertically to the lower face (109) of the liquid crystal display elements (107).

[Patent Document 1] Japanese Patent Application Laid-Open No. 2000-222924

[Patent Document 2] Japanese Patent Application Laid-Open No. 2000-211426

[Disclosure of the Invention]

[Problem to be Solved by the Invention]

[0010]

As shown in Fig. 14 and Fig. 15, in the case of conventional art the general structure is such that the reflective elements (106) formed on the light guide plate (101) are disposed on the reflective face (104) that opposes the exit face (103) of the liquid crystal display elements (107) side, and light deflected by the reflective elements (106) and output from the exit face

(103) is input to the lower face (109) of the liquid crystal display elements (107) via the optical sheet (108). However, a fairy precise configuration design is required in order to bring the reflective elements (106) proper in this structure.

[0011]

Fig. 16 is a plan view showing the distribution of light output from a light guide plate of conventional art.

[0012]

Here for example, light output from the light emitting diode (102) light source enters the light guide plate (101) via the entry face (105), however in the region of the entry face (105) a light ray from the light emitting diode (102) point light source, spreads out in a fan shape as it is guided inside the light guide plate (101) and dark regions occur in the area between the neighboring light emitting diodes (102). Further, light from light emitting diodes (102) may be subject to bright line or hotspots such as pulsating shades of light or the appearance eyeball like glows or the like in the vicinity of the entry face (105) due to the intensity of the light rays.

[0013]

The design of the reflective elements (106) is now under improvement. However, since light deflected by the reflective elements (106) is immediately emitted from the exit face (103) of the light guide plate (101) to the liquid crystal display elements (107) via the optical sheet (108), there may generate hotspots (111) or bright line (112) and dark regions (113) in the area between the neighboring light emitting diodes (102)

due to shortage of light. Accordingly, conventional backlight devices had low light usage efficiency.

[0014]

The present invention is proposed in the light of the above described conditions and has as its objectives, the provision of a backlight device with improved light usage efficiency and a liquid crystal display device providing this backlight device.

[Means for Solving the Problems]

[0015]

In order to overcome the above described issues, according to the backlight device related to the present invention, the light guide plate has an entry face on a side face thereof and reflective elements are arranged on the upper face of the side facing the liquid crystal display elements. Light reflected at the reflective elements at the upper face is output from the lower face toward the reflector.

[0016]

The backlight device related to this invention has at least a light source, a light guide plate and a reflector wherein the light guide plate further provides an entry face into which light from the light source is incident, a lower face substantially perpendicular to the entry face and that opposes the reflector, and an upper face that opposes the lower face; the light guide plate guides light entering from the entry face such that the light undergoes total reflection between the upper face and the lower face; and reflective elements that reflect light such that light is emitted from the lower face toward the

reflector are disposed on the upper face of the light guide plate integrally with the light guide plate.

[0017]

It is preferable that reflective grooves that reflect light output from the lower face of the light guide plate to the light guide plate side be disposed on the surface of the reflector.

[0018]

Further, it is preferable for a metallic film to be disposed on the face of the reflector.

[0019]

Moreover, it is preferable for the light guide plate to be comprised of polymethyl metacrylate, a polyolefine resin, polycarbonate or a compound of these.

[0020]

Again, it is preferable that the distance between the upper face and the lower face of the light guide plate be 0.3-3 .0 mm.

[0021]

It is also preferable that the reflective elements be formed by disposing a plurality of V-shaped grooves on the upper face of the light guide plate substantially parallel to the entry face.

[0022]

It is preferable that the reflective elements comprise the first face that is inclined toward the side of the light guide plate closest to the light source when viewed from inside the light guide plate and the second face that is inclined toward

the face opposite the light source when viewed from inside the light guide plate, and the angle $\theta 1$ formed between the first face and the upper face is 0.2-5° and the angle $\theta 2$ formed between the second face and the upper face is not more than 90°.

[0023]

Further, it is preferable that an anisotropic diffusion pattern be formed as an integrated body with the lower face of the light guide plate.

[0024]

Again, it is preferable that the anisotropic diffusion pattern be a surface relief hologram.

[0025]

Moreover, it is preferable that an optical sheet that deflects light emitted from the light guide plate such that the approach of the traveling direction of the light is the direction normal to the upper face of the light guide plate be disposed in a position opposing the upper face of the light guide plate.

[0026]

The liquid crystal display device related to the present invention has this backlight device and liquid crystal display elements illuminated by this backlight device.

[Effect of the Invention]

[0027]

The present invention realizes a backlight device and liquid crystal display device that uses light more efficiently.

[Best mode for Carrying out the Invention]

[0028]

An embodiment of the light guide plate and backlight device according to the present invention will now be described with reference to the drawings.

[0029]

For simplicity, in these drawings, like reference numerals identify like elements. Further, the drawings of the embodiments of the present invention are provided in order to illustrate the content of the invention but are not intended to accurately reflect the relative proportions of each of the parts.

[0030]

To enable ease in referencing, an orthogonal xyz coordinate system is set over some of the drawings. The x-axis and the y-axis are set in the two sides of the upper face and the lower face of the light guide plate in the direction of travel of light in the light guide plate, and the z-axis is set in the direction of the normal to the upper face and the lower face. Further, the positive and negative directions of the z axis are termed upwards and downwards.

[0031]

Fig. 1 shows the configuration of the liquid crystal display device according to an embodiment of the present invention. Fig. 1 (a) is a side view from that side of the device nearest the light emitting diode light source; Fig. 1 (b) is a side view from a perpendicular direction to Fig. 1 (a).

[0032]

This liquid crystal display device provides a light

emitting diode (2) light source, a light guide plate (1) that guides a light ray (100) that enters therein from the light emitting diodes (2), a reflector (10) disposed substantially parallel to the light guide plate (1), that reflects the light ray (100) emitted from the light guide plate (1), an optical sheet (8) disposed substantially parallel to and directly above the light guide plate (1) with the light guide plate disposed between itself and the reflector (10), that operates to direct a light ray (100) that has been reflected at the reflector (10) and has passed the light guide plate (1), in the direction of the liquid crystal display elements (7), and the liquid crystal display elements (7) disposed substantially parallel to the light guide plate (1) in a position opposing the light guide plate (1) with the optical sheet (8) between the light guide plate (1) and itself, into which a light ray (100) from the optical sheet (8) enters.

[0033]

Within this liquid crystal display device the light emitting diodes (2), the light guide plate (1), the reflector (10) and the optical sheet (8) comprise a backlight device that illuminates the liquid crystal display elements (7) from the rear.

[0034]

Fig. 2 shows the light guide plate. Fig. 2 (a) is a plan view of the light guide plate, Fig. 2 (b) is a side view of the light guide plate and Fig. 2 (c) is a perspective view of the light guide plate. In these drawings, the light emitting diodes

(2) light sources are shown.

[0035]

The light guide plate (1) is comprised of a transparent material having a determined refractive index and has a substantially planar form having an upper face (3) and a lower face (4) that are both substantially rectangular shaped. Referring to the coordinate axis, the entry face (5) of the light guide plate (1) comprises the part into which light rays from the end face between the lower face (4) and the upper face (3) substantially parallel with the x y plane, are entered.

[0036]

In order to alleviate darkness between the light emitting diodes (2) providing the light sources and a hotspot or bright line, the reflective elements (6) of the light guide plate (1) are disposed on the upper face (3) opposing the liquid crystal display elements (7) so as to avoid or alleviate reflected light from the reflective elements (6) being output in the direction of the liquid crystal display elements (7), a light ray (100) reflected by the reflective elements (6) being deflected in the direction of the reflector (10) and then emitted outside of the light guide plate (1). That is to say, the light guide plate (1) guides light rays to the reflector (10) face.

[0037]

A light ray (100) incident to the light guide plate (1) from the light emitting diodes (2) in the xy plane is reflected and deflected in the - z axial direction by the reflective elements (6) integratedly formed on the upper face (3) on that side of

the light guide plate (1) nearer the liquid crystal display elements (7), a part of this light passing the lower face (4) that opposes the upper face (3) before reaching the reflector (10) face.

[0038]

The lower face (4) that opposes the upper face (3) of the light guide plate (1) may be a mirror face or a coarse face, but for this embodiment of the present invention, an anisotropic diffusion pattern layer (18) capable of diffusing light anisotropically is integratedly formed thereon. This anisotropic diffusion pattern layer (18) further improves darkness occurring between the light emitting diodes (2) light source and a hotspot or bright line.

[0039]

The anisotropic diffusion pattern layer (18) is a hologram (anisotropic diffusion pattern) having anisotropic properties formed on the lower face (4). This hologram is called a surface relief hologram to distinguish it from a three dimensionally formed hologram. This anisotropic diffusion pattern layer (18) is large in the direction between the light emitting diodes (2) light sources (the y axial direction) and smaller in the direction between the entry face (5) and an anti-entry face (15) opposing this entry face (5) (the x axial direction), and diffuses light anisotropically. Further, the anisotropic diffusion pattern layer (18) is formed integratedly with the light guide plate (1) providing a concave/convex pattern formed from a surface relief hologram.

[0040]

Light rays (100) reflected and deflected by the reflective elements (6) formed on the upper face (3) of the light guide plate (1) are reflected in the direction of the anisotropic diffusion pattern layer (18) formed as an integrated body with the lower face (4) that opposes the upper face (3), while a part of the light is passed through the lower face (4). At this time the light is diffused at the anisotropic diffusion pattern layer (18) before reaching the face of the reflector (10).

[0041]

The light rays (100) reflected at the reflective elements (6) are substantially diffused at the hologram in the direction between the light emitting diodes (2) light sources in order to alleviate a deficiency of light rays arising between the light emitting diodes (2) light sources and are diffused into what is substantially an elliptical form from the anisotropic diffusion pattern layer (18), before being emitted toward the reflector (10).

[0042]

In this way, the reflective elements (6) reflect light input from the entry face (5) and fulfill a role of deflecting light in the direction of the anisotropic diffusion pattern layer (18). The reflective elements (6) are formed continuously or discontinuously from one side face of the light guide plate (1) to the other side face, and the greater part of the reflective elements (6) are used for reflecting light. Accordingly, the upper face (3) on which are formed the reflective elements (6)

as in this embodiment, has a high degree of efficiency in reflecting incident light in the direction of the anisotropic diffusion pattern layer (18), thereby realizing an improved degree of efficiency in the usage of light by this light guide plate (1).

[0043]

The light guide plate (1) having the form as described above can be produced by extrusion molding in the appropriate mold of a material such as PMMA, polyolefin or polycarbonate.

[0044]

Fig. 3 shows the reflector. Fig. 3 (a) is a perspective view of an example of the reflector, Fig. 3 (b), a perspective view of another example of a reflector.

[0045]

The reflector (10) has the function of reflecting light rays guided by the reflective elements (6) of the light guide plate (1). Reflective grooves (16) for guiding light rays in a determined direction in the upper face (3) side of the light guide plate (1) are formed on this reflector. Further, a metal deposition layer (17) of silver or the like, is formed on the face of the reflective grooves shaped reflector (10) to improve reflective efficiency.

[0046]

Moreover, the reflective grooves (16) shape of the reflector (10) is a shape that enables efficient entry of light rays in a direction in which the optical sheet (8) positioned between the light guide plate (1) and the liquid crystal display

elements (7) can improve frontal luminance. Light rays reaching the reflective grooves (16) formed on the face of the reflector (10) and the metal deposition layer (17) providing the surface layer can be deflected to a direction or an angle different to that of incident light due to the effect of mirror reflection.

[0047]

The reflective grooves (16) formed on the reflector (10) need not necessarily have the same form in entirety. It is possible that the form of the reflective grooves (16) in the vicinity of the upper face (3) of the light guide plate (1) be different to the form of other parts of the reflective grooves (16), thereby enabling the reflective grooves (16) to provide different functions. For example, it is possible for the reflective grooves (16) to provide a form that chiefly facilitates diffusion of light in the vicinity of the upper face (3), while other parts of the reflective grooves (16) may function to efficiently return light rays output from the light guide plate (1) to the reflector (10) back inside the light guide plate (1), or, the reflective grooves (16) may function to reflect those light rays at an angle that enables the light rays to efficiently reach the reflective elements (6) integratedly formed on the light guide plate (1). Further, by forming the shape of the reflective grooves (16) appropriately, it is possible for light to be concentrated and output from the light guide plate (1) in the direction of the liquid crystal display elements (7).

[0048]

The above described configuration enables this embodiment to provide a backlight device and liquid crystal display elements in which the problems of hotspots or bright line occurring in the region of the light entry face (3) of the light guide plate (1) or of darkness arising between the light emitting diodes (2) light sources that afflict conventional technology to be alleviated.

[0049]

Fig. 4 shows the dimensions of each part of the light guide plate.

[0050]

The distance a between the upper face (3) and anisotropic diffusion pattern layer (18) is generally determined by the type (the characteristics) of the light emitting diodes (2) light sources, however, this distance should be within the range from 0.3-3.0 mm, preferably 0.5-1 .0 mm and more preferably still 0.6-0 .8 mm. The angle θ1 formed between the first face (6_1) of the reflective elements (6) and the upper face (3) should be between 0.2-5°, preferably 0.3-3.0° and more preferably still 0.3-1.5°. The angle θ2 between the second face (6_2) of the reflective elements (6) and the upper face (3) should be not greater than 90°, preferably 50-87° and more preferably still 75-80°. Here, viewed from inside the light guide plate (1), the first face (6_1) is inclined toward the light emitting diodes (2) light sources side of the light guide plate (1), and the second face (6_2) is inclined toward the side opposite that side closer to the light emitting diodes (2).

[0051]

The interval p between neighboring reflective elements (6) should be uniform, and preferably within the range 500-500 µm, more preferably 50-250 µm and more preferably still 100-150 µm. Note that if the interval p is made uniform a moire phenomena arises due to interference from the cell arrangement of the liquid crystal display elements (7), therefore this interval can intentionally be made random.

[0052]

Fig. 5 shows the optical path within the light guide plate.

[0053]

Light rays (100) incident to the entry face (5) of the light guide plate (1) from the light emitting diodes (2) undergo total reflection while traveling within the light guide plate (1), between the lower face (4) integratedly formed with the anisotropic diffusion pattern layer (18) and the upper face (3), until a critical angle formed with the anisotropic diffusion pattern layer (18) or the lower face (4) is reached.

[0054]

The first face (6_1) of the reflective elements (6) performs the role of deflecting light to be reflected in the direction of the anisotropic diffusion pattern layer (18). As the angle formed between the angle of incidence of light that enters the entry face (5) and the upper face (3) is small, the incident light is deflected in the direction of the anisotropic diffusion pattern layer (18) as it is reflected to the first face (6_1) of the reflective elements (6), and when the angle of this

traveling light and the anisotropic diffusion pattern layer (18) exceeds a critical angle, the light is output from the anisotropic diffusion pattern layer (18).

[0055]

Here, to the extent that the angle $\theta 1$ formed between the first face (6_1) of the reflective elements (6) and the anisotropic diffusion pattern layer (18) is small, the light is gradually pointed upward due to reflection at the first face (6_1) of the reflective elements (6), thus the direction of light output from the light guide plate (1) is collimated. The light thus arranged can be easily managed, but light extracted from the anisotropic diffusion pattern layer (18) is further deflected by the reflective grooves (16) formed on the face of the reflector (10) and the metal deposition layer (17) formed on the face of the reflective grooves (16), and the light rays are reflected in the direction of the light guide plate (1) again.

[0056]

These light rays are further diffused at the anisotropic diffusion pattern layer (18) and are directed toward the upper face (3). At this time, as the traveling direction of the light rays is set to an angle below the angle for total reflection in relation to the faces of the anisotropic diffusion pattern layer (18) and the reflective elements (6), light reflected from the metal deposition layer (17) and the reflective grooves (16) of the reflector (10) is emitted from the upper face (3) of the light guide plate (1). Light rays emitted from the light guide plate (1) undergo a determined deflection at the optical sheet

(8) before entering the lower face (9) of the liquid crystal display elements (7).

[0057]

A concrete example of this embodiment of the present invention will now be described, provided that this example is illustrative and not restrictive in the application of the invention. In the light guide plate (1) of this embodiment the shape of the reflective elements (6) employs a V-shaped form as shown in Fig. 5.

[0058]

The angle between the inclination of the reflective elements (6) and the upper face (3) ($\theta 1$) is 1.7º, the intervals between the reflective elements (6) being constant, disposed from the corner part (19) and the intersection of the entry face (5) at a pitch of 120 µm (p = 120 µm). As shown in Fig. 5 the mold for the light guide plate (1) is prepared having V shaped grooves such that the first face (6_1) is directed to face the light emitting diodes (2) so that the angle of inclination brings light from the entry face (5), gradually to an angle below that angle for total reflection and the light guide plate is produced by extrusion processes using the mold. Further, for this embodiment, the anisotropic diffusion pattern layer (18) that diffuses light anisotropically and is provided by a surface relief hologram integratedly formed with the lower face (4) facing the upper face (3).

[0059]

Fig. 6 is a plan view, for the purpose of providing a

comparative example, showing the distribution of light emitted from a backlight device that does not employ an anisotropic diffusion pattern layer (18) of the surface relief hologram. In this example a light ray that enters from the entry face (5) of the light guide plate (1) passes the lower face (4) that is made a mirror face instead of the anisotropic diffusion pattern layer (18) and is reflected by the light guide plate (1), passes the reflector (1) and in the condition in which it is emitted, bright line (12) as shown in Fig. 6 occurs. For this reason, it is preferable for a pattern that can diffuse light to be formed on the lower face (4) facing the reflective elements (6). Further it is preferable in order to improve frontal luminance that diffusion is substantial in the direction between the light emitting diodes (2) light sources and is smaller in the direction between the anti-entry face (15) and the light emitting diodes (2) light source.

[0060]

For the embodiment according to the present invention, the hologram formed by the anisotropic diffusion pattern layer (18) diffuses substantially in the direction between the light emitting diodes (2) light sources while the diffusion of light is smaller in the direction between the anti-entry face (15) and the light emitting diodes (2) light sources. Further, each of the half value diffusion angles use a pattern having 60° in the direction between the light sources and 1° in the other direction.

[0061]

Fig. 7 shows a hologram formed as an anisotropic diffusion pattern that forms an integrated layer (18). Fig. 8 shows the hologram enlarged 200 times.

[0062]

As shown in Fig. 7, a plurality of speckles (21) of a substantially elliptical shape are formed with the longitudinal axis thereof being the direction between the light emitting diodes (2) light sources and the anti-entry face (15), that is to say, the x axial direction in the drawing, such that diffusion is smaller in the direction between the anti entry face (15) and the light sources (the x axial direction) while diffusion is substantial in the direction between the light emitting diodes (2) light sources (the y axial direction).

[0063]

The light rays (100) that undergo total reflection and are deflected at the V-shaped reflective elements (6) integratedly formed on the upper face (3), a portion thereof that reach the anisotropic diffusion pattern layer (18) are reflected to the reflector (10) side of the light guide plate (1). When a light ray (100) that has undergone total reflection and deflection at the V-shaped reflective elements (6) reaches the anisotropic diffusion pattern layer (18), the angle of total reflection is lost as the anisotropic diffusion pattern layer (18) has a coarse face (see Fig. 8), so a part of the light rays pass toward the reflector (10) side of the light guide plate (1). When the light rays (100) thus passing toward the reflector (10) side are emitted from the light guide plate (1), these light

rays are anisotropically diffused due to the diffusion effect of the hologram and the light is diffused substantially in the direction between the light emitting diodes (2) light sources, reaching the reflector (10).

[0064]

Fig. 9 is an explanatory drawing illustrating the properties of the hologram.

[0065]

Fig. 9 (a) is a plan view showing angle dependence of the luminance of light emitted from the points P1, P2, and P3 of the anisotropic diffusion pattern layer (18) of the light guide plate (1). Fig. 9 (b) is a perspective view showing in solid form, the strength distribution of light emitted from the point P2 of the anisotropic diffusion pattern layer (18) of the light guide plate (1).

[0066]

Due to the effect of the hologram formed on the anisotropic diffusion pattern layer (18), light emitted from the points P1, P2 and P3 of the anisotropic diffusion pattern layer (18) of the light guide plate (1) diffuses substantially in the direction between the light emitting diodes (2) light sources as shown by the ellipses E1, E2 and E3, while the light diffuses less in the direction between the anti-entry face (15) and the light emitting diodes (2). The ratio of the longitudinal axial direction and the shorter axial direction of the ellipses E1, E2 and E3 that shows the strength distribution of the diffused light is changeable, but in the case of this embodiment this

ratio is 1: 60.

[0067]

Fig. 10 is a block diagram showing the configuration of the device used for forming the master hologram.

[0068]

The hologram formed by the anisotropic diffusion pattern layer (18), is a copy of a master hologram and has the same optical properties as the master hologram.

[0069]

The device shown in Fig. 10 has a laser light source (71) for emitting laser light of a determined wavelength, a mask (72) having an opening of for example a rectangular shape, a mask (73) for passing light only of desired regions, and a table (75) that supports the photoresist (74) such that the photoresist (74) is movable in the planar direction.

[0070]

The laser light source (71) can switch between the red, green and blue (RGB) elements of the laser light and emit the light. This is because in order to produce a hologram that diffuses the white light required for illuminating the liquid crystal display device of for example a mobile telephone device, it is necessary to expose each of the RGB elements of the laser light to the photoresist (74). Three laser light sources emit respectively one of the RGB elements, and a switch occurs between these different light sources as the device is used.

[0071]

The mask (72) has an opening provided by a rectangular

shaped diffuser. Frost glass for example can be used for this diffuser. The dimensions of the respective long and short sides of the rectangular shape correspond respectively to the dimensions of the short and long axes of the substantially elliptical speckles formed on the photoresist (74). Note that the relationship between the long and short sides and the short and long axes is a mutual relationship of Fourier transformation.

[0072]

The mask (73) is used such that light is exposed only to the required regions of the photoresist (74). The hologram according to this embodiment does not expose light at once to all of the photoresist (74), but rather the appropriate parts are exposed so that each part obtains the desired diffusion characteristics. Multiple light exposures are performed repeatedly to each part until the photoresist (74) has been exposed entirely. This multiple light exposure is performed for each of the respective RGB elements. Once the hologram thus exposed to light is developed the master hologram is obtained.

[0073]

The photoresist (74) is a thick film uniformly distributed with a highly photosensitive body such that extremely weak light can be detected and the speckles faithfully reproduced.

[0074]

The supporting base (75) is used to move the photoresist (74) in the planar direction. The table (75) moves the photoresist (74) when changing the position of light exposure to the photoresist (74) and adjusting the distance between the

masks (72) and (73), and the photoresist (74).

[0075]

Fig. 11 is a perspective view showing the configuration of a device used for forming the master hologram.

[0076]

The masks (81) and (82) are equivalent to the mask (72) having the rectangular shaped opening shown in Fig. 10. The mask (81) has a slit (81a). The short side of the rectangular shaped opening is determined by the width of this slit (81a). The mask (82) has a triangular shaped opening (82a). The long side of the rectangular shaped opening is determined by the maximum length in the longitudinal direction of the region of the (82a) of the triangular shaped opening (82) which passes light passing the slit (81a)of the mask (81). The masks (81) and (82) diffuse light passed by a diffuser not shown in the drawing.

[0077]

The mask (83) equates to the mask (73) shown in Fig. 10. This mask (83) has a rectangular shaped opening (83a). The regions of the photoresist (84) that are exposed to light are limited to those parts to which light passing this rectangular shaped opening (83a) reach. The entire face of the photoresist (84) can be exposed to light by changing these parts of the photoresist (84) and performing multiple exposures.

[0078]

A master hologram is obtained when a photoresist is exposed to light using the devices shown in Fig. 10 and Fig. 11 and

developed. A master hologram produced in this way is unevenly transferred in a form of concave/convex to parts corresponding to the lower face (4) of the light guide plate (1) in a mold used for producing the light guide plate (1). This mold to which the master hologram has been transferred is then used to produce the light guide plate (1) by injection molding and the hologram can be integratedly formed as the anisotropic diffusion pattern layer (18) on the lower face (4) of the light guide plate (1).

[0079]

Fig. 12 shows a part of the backlight device formed by the light guide plate and optical sheet.

[0080]

In this backlight device comprising the light guide plate (1) and the optical sheet (8) light emitted from the upper face (3) of the light guide plate (1) includes lights L_1 and L_2, being light elements which form a small angle with the upper face (3). The optical sheet (8) has a flat upper face (51) and a prism shaped lower face (52). When the lights L_1 and L_2 that form a small angle with the upper face (3) of the light guide plate (1) enter from this lower face (52), the angle is changed so as to become a substantial angle with the upper face (51) of the optical sheet (8) and the lights are emitted (L_1' and L_2'). In this way the optical sheet (8) improves the frontal strength of light output to the liquid crystal display elements (7).

[0081]

Fig. 13 shows the optical sheet.

[0082]

This optical sheet (prism sheet) (8) is made of a transparent material such as for example PMMA, polyolefin, polycarbonate or a photoresistant resin. Reflective grooves (53) that form a continuous prism shaped construction are disposed on the lower face (52) opposing the upper face (51). This optical sheet (8) is disposed above the upper face (3) of the light guide plate (1).

[0083]

Although the invention has been described herein by reference to the exemplary embodiment, the invention is not limited thereby, and modifications and variations of the embodiment as described will occur to those skilled in the art, in light of the above teachings. Further, the particular values provided in the above description are intended to provide examples that are illustrative with respect to the invention and not restrictive.

[Brief Description of the Drawings]

[0084]

[FIG. 1]

Fig. 1 shows the configuration of the liquid crystal display device according to an embodiment of the present invention.

[FIG. 2]

Fig. 2 shows the light guide plate of this embodiment.

[FIG. 3]

Fig. 3 shows the reflector of the light guide plate of this embodiment.

[FIG. 4]

Fig. 4 shows the dimensions of each of the parts of the light guide plate.

[FIG. 5]

Fig. 5 shows the optical path in the light guide plate.

[FIG. 6]

Fig. 6 is a plan view, for the purpose of providing a comparative example, showing the distribution of light emitted from a backlight device that does not employ an anisotropic diffusion pattern of the surface relief hologram.

[FIG. 7]

Fig. 7 shows a hologram formed as an anisotropic diffusion pattern that forms an integrated layer.

[FIG. 8]

Fig. 8 shows the hologram enlarged 200 times.

[FIG. 9]

Fig. 9 is an explanatory drawing illustrating the properties of the hologram.

[FIG. 10]

Fig. 10 is a block diagram showing the configuration of the device used for forming the master hologram.

[FIG. 11]

Fig. 11 is a perspective view showing the configuration of a device used for forming the master hologram.

[FIG. 12]

Fig. 12 shows a part of the backlight device formed by the light guide plate and optical sheet.

[FIG. 13]

Fig. 13 shows the optical sheet.

[FIG. 14]

Fig. 14 provides an external view of a conventional light guide plate.

[FIG. 15]

Fig. 15 is a cross-sectional view showing the condition of usage of a conventional light guide plate and backlight device.

[FIG. 16]

Fig. 16 is a plan view showing the distribution of light emitted from a conventional light guide plate.

[Explanation of the Reference Numbers]

[0085]

1	light guide plate
2	light emitting diode
3	upper face
4	lower face
5	entry face
6	reflective elements
7	liquid crystal display elements
8	optical sheet
9	lower face
10	reflector
12	bright line
15	anti-entry face
16	reflective groove
17	metal deposition layer

18 anisotropic diffusion pattern layer

19 corner part

[Name of Document] Abstract

[Abstract]

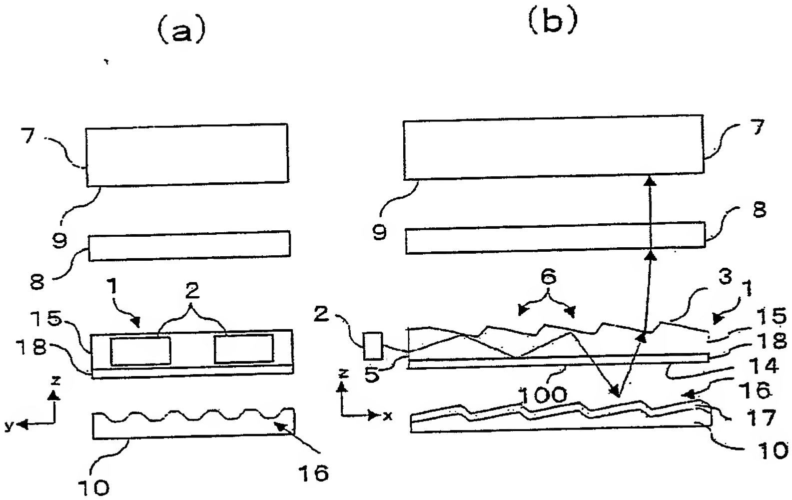
[Object] To provide a backlight device with improved light usage efficiency.

[Solving Means] A backlight device has at least a light emitting diode (2) light source, a light guide plate (1) and a reflector (10) The light guide plate (1) further provides an entry face (5) into which light from the light emitting diode (2) is incident, a lower face (4) substantially perpendicular to the entry face (5) and that opposes the reflector (10), and an upper face (3) that opposes the lower face (4). The light guide plate (1) guides light entering from the entry face (5) such that the light undergoes total reflection between the upper face (3) and the lower face (4). Reflective elements (6) that reflect light such that light is emitted from the lower face (4) toward the reflector (10) are disposed on the upper face (3) of the light guide plate (1) integrally with the light guide plate (1). An anisotropic diffusion pattern layer (18) capable of diffusing light anisotropically is integratedly formed on the lower face (4).

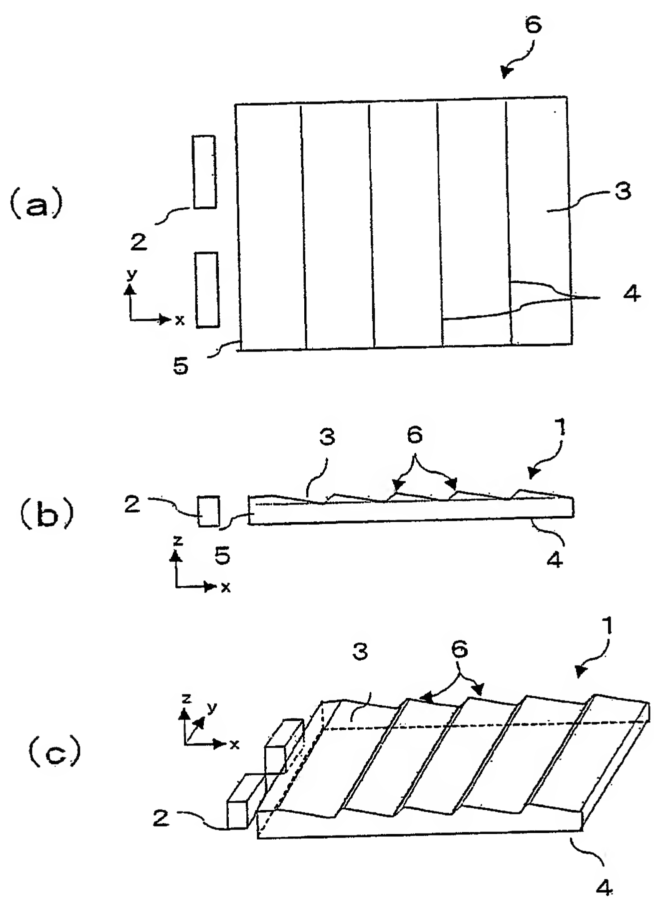
[Selected Figure] Fig. 1

【書類名】図面 [Name of Document] Drawings

【図１】 Fig. 1

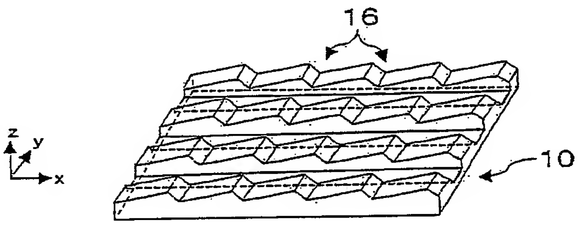


【図２】 Fig. 2

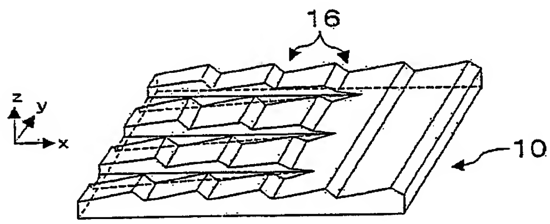


【図３】 Fig. 3

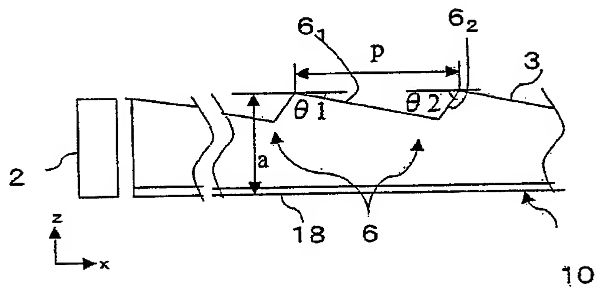
(a)



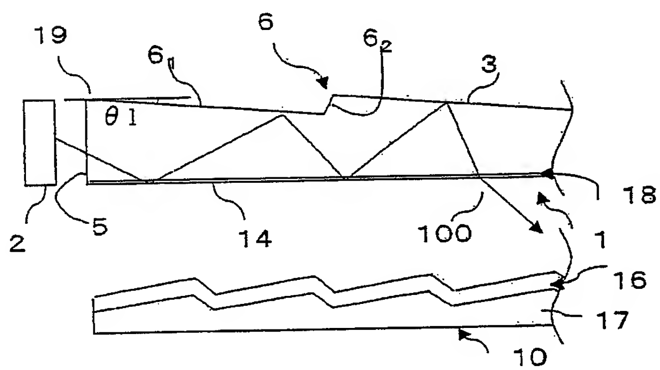
(b)



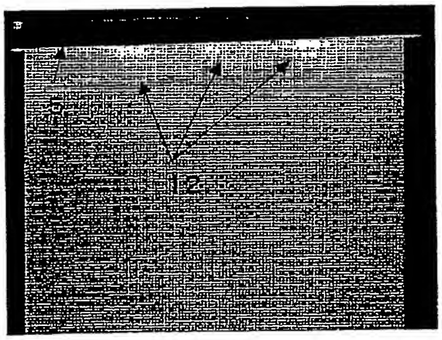
【図４】 Fig. 4



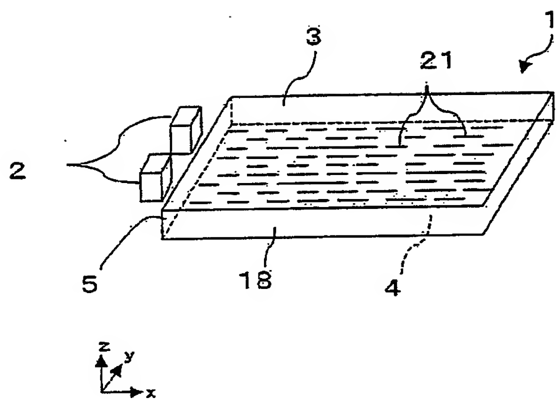
【図５】 Fig. 5



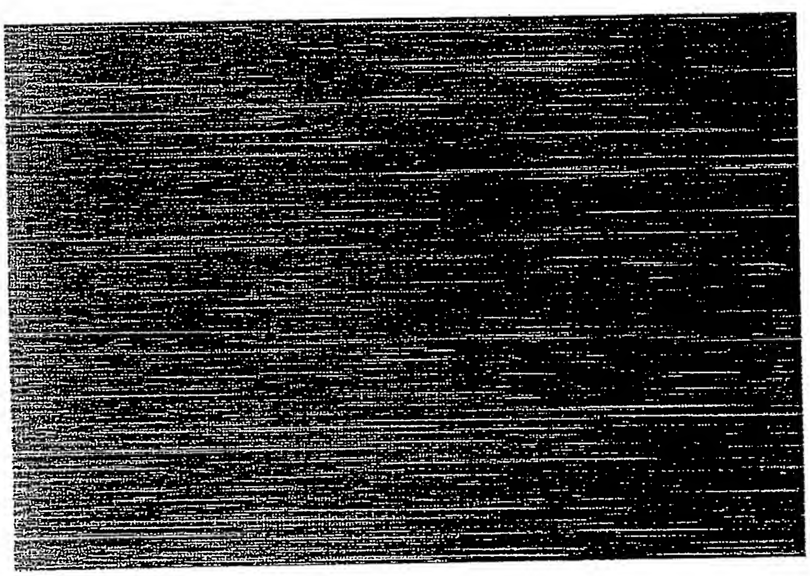
【図６】　Fig. 6



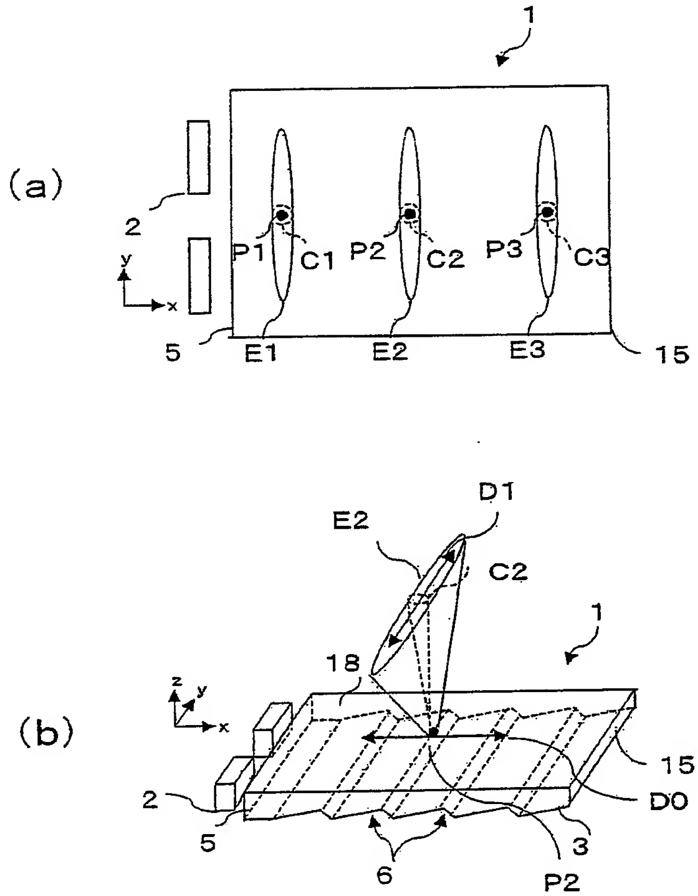
【図７】 Fig. 7



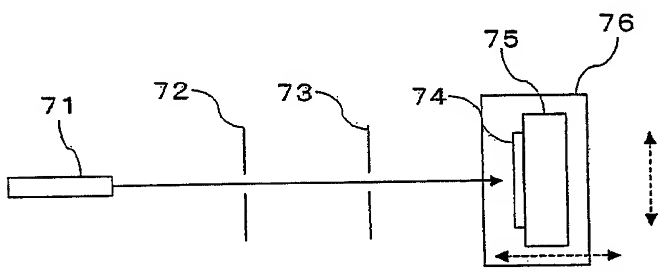
【図８】　Fig. 8



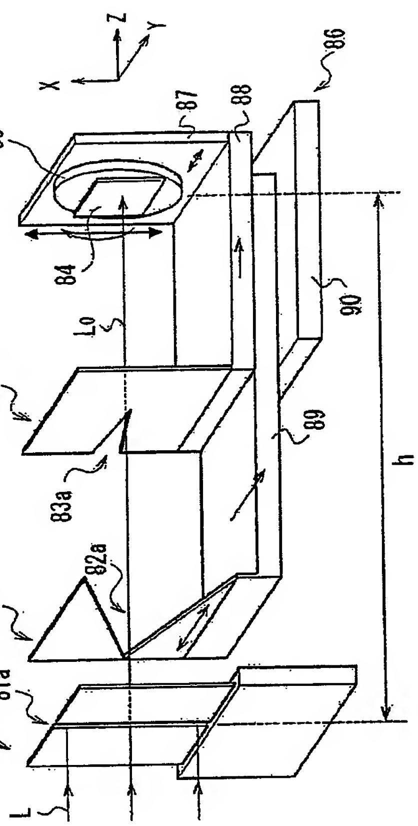
【図９】 Fig. 9



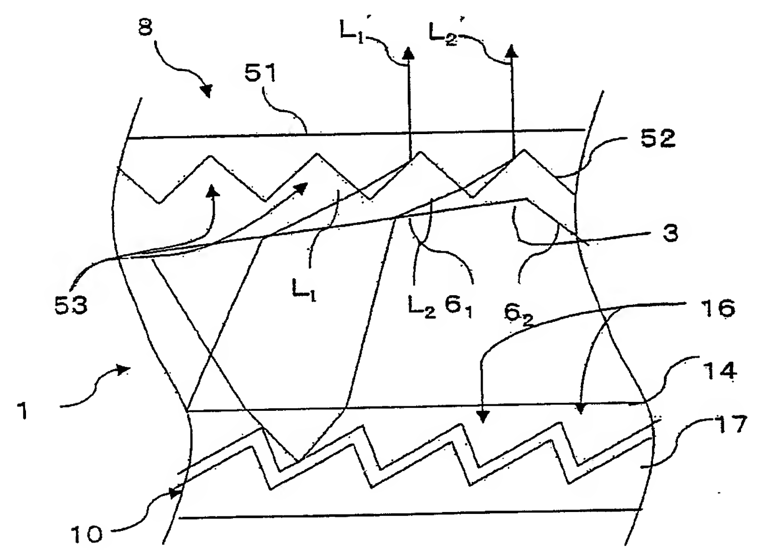
【図１０】 Fig. 10



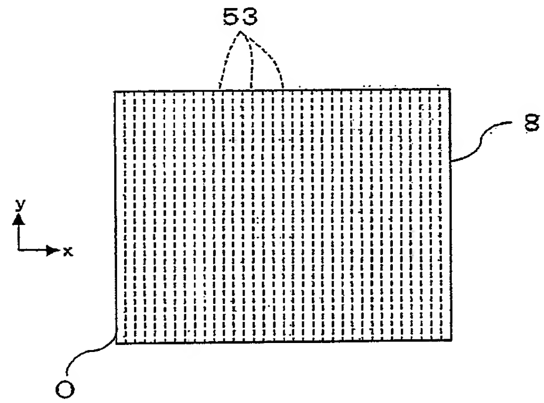
【図１１】　Fig.11



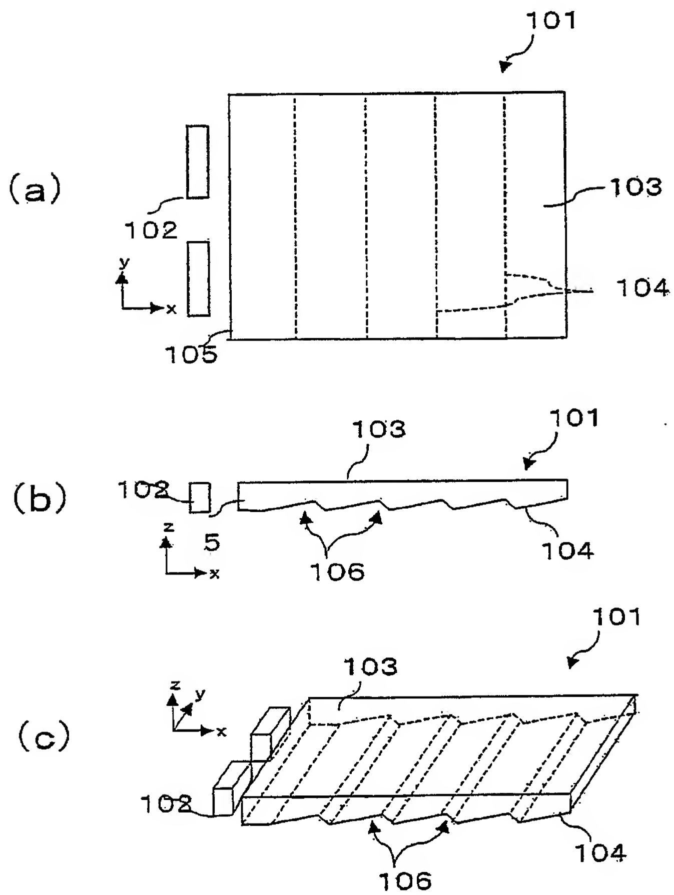
【図１２】　Fig.12



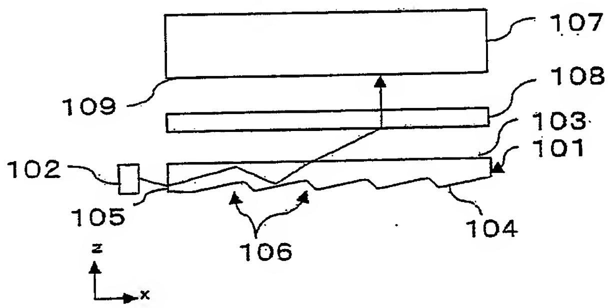
【図１３】 Fig. 13



【図１４】 Fig. 14



【図１５】 Fig.15



【図１６】 Fig.16